Molarity and Dilution, Practice Problems

1) How many grams of potassium carbonate are needed to make 200. mL of a 2.50 M solution?

$0.200\,L \times 2.50\,M\,K_2CO_3 \times \frac{138.2\,g\,K_2CO_3}{1\,mol\,K_2CO_3} = 69.1\,g\,K_2CO_3$

2) What is the concentration of a 450. mL solution that contains 234 grams of iron (II) chloride?

$234\,g\,FeCl_2 \times \frac{1\,mol\,FeCl_2}{126.8\,g\,FeCl_2} = \frac{1.84\,mol\,FeCl_2}{0.450\,L} = 4.10\,L\,FeCl_2$

3) How many liters of 0.880 M solution can be made with 25.5 grams of lithium fluoride?

$25.5\,g\,LiF \times \frac{1\,mol\,LiF}{25.94\,g\,LiF} = 0.983\,mol\,LiF = 1.12\,L$

$\frac{0.983\,mol\,LiF}{0.880\,M\,LiF}$

4) How many liters of 0.75 M solution can be made using 75 grams of lead (II) oxide?

$75\,g\,PbO \times \frac{1\,mol\,PbO}{223.2\,g\,PbO} = 0.336\,mol\,PbO = 0.448\,L$

$\frac{0.336\,mol\,PbO}{0.75\,M\,PbO}$

5) If I have 340 mL of a 0.5 M NaBr solution, what will the concentration be if I add 560 mL more water to it?

$M_1V_1 = M_2V_2 \qquad (0.5\,M)(340\,mL) = M_2(340\,mL + 560\,mL)$

$M_2 = 0.189\,M = 0.2\,M$

6) If I leave 750 mL of 0.50 M sodium chloride solution uncovered on a windowsill and 150 mL of the solvent evaporates, what will the new concentration of the sodium chloride solution be?

$(0.50\,M\,NaCl)(750\,mL) = M_2(750\,mL - 150\,mL)$

$M_2 = 0.625\,M\,NaCl$

7) What is the molarity of a solution of ammonium chloride prepared by diluting 50.0 ml of a 3.79 M stock solution to 2.00 L?

$(0.0500\,L)(3.79\,M) = (M_2)(2.00\,L)$

$M_2 = 0.0948\,M\,NH_4Cl$

8) Describe how to prepare 1.00 L of 0.495 M solution of urea, NH_2CONH_2, starting with a 3.07 M stock solution?

$(3.07\,M)V_1 = (0.495\,M)(1.00\,L)$

$V_1 = 0.161\,L$

Take 161 mL of stock soln by using a pipette into a 1.0L volumetric flask. Then add some water to the flask and stir the soln then add H_2O up to the 1.0L mark of the flask.

Precipitate Reactions

Predict if the following reactions will occur. If they do write the products and balance the equations.

1) ___ $NaOH$ + ___ $CaBr_2$ → $Ca(OH)_2\downarrow + 2NaBr$ $\frac{1}{2}/\frac{1}{2}$

Will this reaction occur? Y

2) ___ $Pb(NO_3)_2$ + 2 HCl → $PbCl_2\downarrow + 2HNO_3$

Will this reaction occur? Y

3) ___ Na_2CO_3 + ___ KF → NR

Will this reaction occur? _____

4) ___ $AgNO_3$ + ___ $CuSO_4$ → [illegible]

Will this reaction occur? [illegible]

5) 2 AgF + ___ $NiCl_2$ → $NiF_2 + 2AgCl\downarrow$

Will this reaction occur? Y

6) ___ $Ba(NO_3)_2$ + ___ $CuSO_4$ → $BaSO_4\downarrow + Cu(NO_3)_2$

Will this reaction occur? Y

7) ___ Na_2S + ___ K_2CrO_4 → NR

Will this reaction occur? NR

8) [illegible] $Hg_2(NO_3)_2$ + 4 (2) Na_3PO_4 → [illegible] $(Hg_2)_3(PO_4)_2\downarrow$ + (6) $NaNO_3$

Will this reaction occur? Y

Write the Net Ionic Equation for each reaction that takes place on the back of this sheet.

1. $Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Ca(OH)_2 \downarrow$ $\frac{1}{2}/\frac{1}{2}$

2 $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow PbCl_2 \downarrow$

~~$Ag^+_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow Ag_2SO_4 \downarrow$~~

5 $Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl \downarrow$

6 $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow BaSO_4 \downarrow$

8 3 6 $Hg_2^{2+} + 2PO_4^{3-} \longrightarrow 2(Hg_2)_3(PO_4)_2$

Predicting Precipitation and Double Replacement Reaction Products

Use solubility rules and knowledge of acid-base reactions to predict the products of these reactions. (some reactions may not occur)

1) $\_\_ CuSO_4 + \_\_ AgNO_3 \rightarrow$ No Rxn

2) $\_\_ NaOH + \_\_ TiCl_2 \rightarrow$ $Ti(OH)_2\downarrow + NaCl$

3) $\_\_ N_2O_5 + \_\_ H_2O \rightarrow$ $2\ HNO_3$

4) $\underline{2}\ HNO_3 + \_\_ Mg(OH)_2 \rightarrow$ $2H_2O + Mg(NO_3)_2$

5) $\_\_ Fe(NO_2)_2 + \_\_ Na_2SO_4 \rightarrow$ $FeSO_4\downarrow + 2NaNO_2$

6) $\underline{2}\ HCN + \_\_ Na_2CO_3 \rightarrow$ $NaCN + H_2O + NaCO_2$

7) $\_\_ H_2O + \_\_ MgO \rightarrow$ $Mg(OH)_2$

8) $\underline{3}\ HNO_3 + \_\_ Fe(OH)_3 \rightarrow$ $3H_2O + Fe(NO_3)_3$

9) $\underline{2}\ Li_2S + \_\_ Co(SO_3)_2 \rightarrow$ $CoS_2\downarrow + 2Li_2SO_3$

10) $\_\_ Fe(NO_3)_3 + \underline{3}\ H_2O \rightarrow$ $Fe(OH)_3 + 3H^+ 3NO_3$

11) $\_\_ H_2O + \_\_ CO_2 \rightarrow$ H_2CO_3

12) $\_\_ H_2O + \_\_ K_2HPO_4 \rightarrow$ $2K^+ + H_2PO_4^- + OH^-$

13) $\_\_ HClO + \_\_ LiOH \rightarrow$ $LiClO + H_2O$

14) $\_\_ P_2O_5 + \underline{3}\ H_2O \rightarrow$ $2H_3PO_4$

15) $\_\_ Na_2CO_3 + \_\_ CaI_2 \rightarrow$ $CaCO_3\downarrow + 2NaI$

Titration Questions

1. How many milliliters of 0.120 M HCl are neededto completely neutralize 50.0 mL of 0.101 M $Ba(OH)_2$ solution?

$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$

$50.0\,mL \times 0.101\,M\,Ba(OH)_2 \times \frac{2\,mol\,HCl}{1\,mol\,Ba(OH)_2} \times = \frac{10.1\,mmol\,HCl}{0.120\,M\,HCl} = \boxed{84.2\,mL}$

2. What volume of 0.128 M HCl is needed to neutralize 2.87 g of magnesium hydroxide?

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

$2.87\,g\,Mg(OH)_2 \times \frac{1\,mol\,Mg(OH)_2}{58.3\,g\,Mg(OH)_2} \times \frac{2\,mol\,HCl}{1\,mol\,Mg(OH)_2} = \frac{0.0985\,mol\,HCl}{0.128\,M} = \boxed{0.769\,L}$

3. If 25.00 mL of 0.100 M HBr is titrated with 0.200 M NaOH, how many milliliters of NaOH are required to reach the equivalence point? **DO NOT USE A CALCULATOR FOR THIS PROBLEM**

$HBr + NaOH \rightarrow NaCl + H_2O$

$25.00\,mL \times \frac{0.100\,mmol\,HBr}{1} \times \frac{1\,mol\,NaOH}{1\,mol\,HBr} \times \frac{X\,mL\,NaOH}{0.200\,mmol\,NaOH} = \boxed{12.50\,mL\,NaOH}$

4. A sample of solid calcium hydroxide is stirred in water at 30.0°C until a saturated solution is formed. A 100. mL sample of this solution is withdrawn and titrated with 5.00×10^{-2} M HBr. It requires 48.8 mL of the acid for neutralization. What is the molarity of the calcium hydroxide solution? What is the solubility of calcium hydroxide in water, at 30.0°C, in grams of calcium hydroxide per 100. mL of solution?

$2HBr + Ca(OH)_2 \rightarrow 2H_2O + CaBr_2$

$48.8\,mL \times 5.00 \times 10^{-2}\,mmol\,HBr \times \frac{1\,mmol\,Ca(OH)_2}{2\,mmol\,HBr} = \frac{1.22\,mmol\,Ca(OH)_2}{100\,mL} = \boxed{0.0122\,M\,Ca(OH)_2}$

$0.0122\,M\,Ca(OH)_2 \times 0.100\,L = 0.00122\,mol\,Ca(OH)_2 \times \frac{74.8\,g\,Ca(OH)_2}{1\,mol\,Ca(OH)_2} = \boxed{\frac{0.0913\,g\,Ca(OH)_2}{100\,mL}}$

5. The quantity of chloride ions in a town water supply is determined by titrating the sample with silver ions. The endpoint of the titration is marked by a change in color of a specific type of indicator. How many grams of chloride ion are in a sample of the water if 20.2 mL of 0.100 M silver ions is needed to react with all of the chloride ions in the sample. If the sample has a mass of 10.0 g, what percent of chloride does it contain?

$Ag^+ + Cl^- \rightarrow AgCl\downarrow$

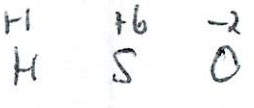
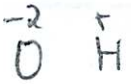
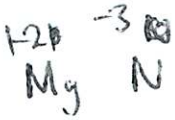
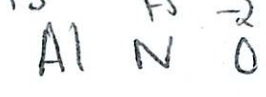
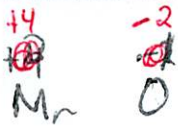
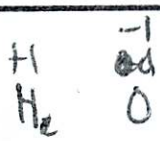
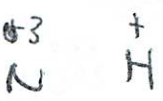
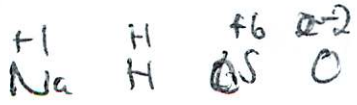
$20.2\,mL \times \frac{1\,L}{1000\,mL} \times 0.100\,M\,Ag^+ \times \frac{1\,mol\,Cl^-}{1\,mol\,Ag^+} \times \frac{35.45\,g\,Cl^-}{1\,mol\,Cl^-} = \boxed{0.0716\,g\,Cl^-}$

$\frac{0.0716\,g\,Cl^-}{10.0\,g\,Cl^-} \times 100\% = \boxed{0.716\%\,Cl}$

...ING OXIDATION NUMBERS

Name _____

...dation numbers to all of the elements in each of the compounds or ions below.

1. HCl 	11. H_2SO_3 
2. KNO_3 	12. H_2SO_4 
3. OH^- 	13. BaO_2 
4. Mg_3N_2 	14. $KMnO_4$ 
5. $KClO_3$ 	15. LiH 
6. $Al(NO_3)_3$ 	16. MnO_2 
7. S_8 	17. OF_2 
8. H_2O_2 	18. SO_3 
9. PbO_2 	19. NH_3 
10. $NaHSO_4$ 	20. Na 

REDOX REACTIONS

Name _____

For the equations below, identify the substance oxidized, the substance reduced, the oxidizing agent, the reducing agent, and write the oxidation and reduction half reactions

Example: $\overset{\text{reducing agent}}{Mg} + \overset{\text{oxidizing agent}}{Br_2} \rightarrow MgBr_2$

oxidized reduced

oxidation half reaction: $Mg^{\circ} \rightarrow Mg^{+2} + 2e^-$

reduction half reaction: $2e^- + Br_2^{\circ} \rightarrow 2Br^-$

1. $2H_2 + O_2 \rightarrow 2H_2O$

Oxid red

reagent oxidant

Ox $H_2 \rightarrow 2H^+ + 2e^-$

Red $2e^- \; O_2 \rightarrow 2O^{2-}$

2. $Fe + Zn^{2+} \rightarrow Fe^{2+} + Zn$

ox red

reagent oxidant

Ox $Fe \rightarrow Fe^{2+} + 2e^-$

Red $2e^- + Zn^{2+} \rightarrow Zn$

3. $2Al + 3Fe^{+2} \rightarrow 2Al^{+3} + 3Fe$

Ox red

reagent oxidant

Ox $Al \rightarrow Al^{3+} + 3e^-$

red $2e^- + Fe^{2+} \rightarrow Fe$

4. $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

Ox red

reagent oxidant

Ox $Cu \rightarrow Cu^{2+} + 2e^-$

red $e^- + Ag^+ \rightarrow Ag$

Solution Stoichiometry

When an excess of calcium metal reacts with 40.0 mL of 3.20 M hydrochloric acid, what mass of calcium chloride will be produced? Assuming no volume changes to the solution, what is the concentration of the resulting salt? $Ca + 2HCl \rightarrow CaCl_2 + H_2$ ne $Ca + 2H^+ \rightarrow Ca^{2+} + H_2$

$0.0400L \times 3.20M\ HCl \times \frac{1mol\ CaCl_2}{2mol\ HCl} = 0.064 mol\ CaCl_2 \times \frac{110.98g\ CaCl_2}{1mol\ CaCl_2} = \boxed{7.10g\ CaCl_2}$

$\frac{0.064mol\ CaCl_2}{0.0400L} = \boxed{1.60M\ CaCl_2}$

When 100.0 mL of 1.00 M potassium sulfide reacts with an excess of nickel (II) nitrate, what mass of precipitate is produced? $K_2S + Ni(NO_3)_2 \rightarrow NiS + 2KNO_3$ $S^{2-} + Ni^{2+} \rightarrow NiS$

$0.100L \times 1.00M\ K_2S \times \frac{1mol\ NiS}{1mol\ K_2S} \times \frac{90.76g\ NiS}{1mol\ NiS} = \boxed{9.08g\ NiS}$

If 5.10 mL of 3.77 mM sodium hydroxide is combined with an equal volume of 5.87 mM sulfuric acid, what is the resulting concentration of the excess reactant? What is the resulting concentration of the salt produced? $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$ $H^+ + OH^- \rightarrow H_2O$

$0.00510L \times 3.77mM = 0.0192 mmol\ NaOH \times \frac{1mol\ H_2SO_4}{2mol\ NaOH} = 0.0096 mmol\ H_2SO_4$ $0.0192mmol\ NaOH \times \frac{1mol\ Na_2SO_4}{2mol\ NaOH} = 0.0096mmol$

$0.00510L \cdot 5.87mM = 0.0299 mmol\ H_2SO_4$

$0.0299mmol\ H_2SO_4 - 0.0096mmol\ H_2SO_4 = 0.0203mmol\ H_2SO_4$ $\frac{0.0203mmol\ H_2SO_4}{0.01020L} = \boxed{1.99mM\ H_2SO_4}$

$\frac{0.0096mmol}{0.0102L} = 0.941$

When chlorine gas is bubbled into 760. mL of 2.10 M lithium iodide, how many molecules of chlorine are needed to convert all of the lithium iodide to lithium chloride? $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$

$Cl_2 + 2LiI \rightarrow 2LiCl + I_2$ 6.022×10^{23}

$0.760L \times \frac{2.10mol\ LiI}{} = 1.60mol\ LiI \times \frac{1mol\ Cl_2}{2mol\ LiI} \times \frac{1mol\ Cl_2}{1mol\ Cl_2} = \boxed{4.81 \times 10^{23} molec\ Cl_2}$

If magnesium sulfate crystals are dissolved in 50.0 mL of 0.100 M strontium nitrate a precipitate forms. If the entire amount of strontium nitrate is consumed, how many grams of magnesium sulfate were used? $MgSO_4 + Sr(NO_3)_2 \rightarrow SrSO_4 + Mg(NO_3)_2$ $Sr^{2+} + SO_4^{2-} \rightarrow SrSO_4$

$50.0mL \times \frac{1L}{1000L} \times \frac{0.100mol\ Sr(NO_3)_2}{} \times \frac{1mol\ MgSO_4}{1mol\ Sr(NO_3)_2} \times \frac{120.3g\ MgSO_4}{1mol\ MgSO_4} = 0.602g\ MgSO_4$

Redox Reactions

Balance the following oxidation reactions. Acidic and basic conditions will be specified. Indicate which substances are oxidized and which are reduced.

Zinc metal reacts with hydrochloric acid

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

$$Br_{2(g)} + S_2O_3^{2-}{}_{(aq)} + H_2O \rightarrow Br^-_{(aq)} + SO_4^{2-}{}_{(aq)} + H^+_{(aq)}$$

$$2 KMnO_{4(aq)} + 16 HCl_{(aq)} \rightarrow 2 MnCl_{2(aq)} + 5 Cl_{2(g)} + 8 H_2O + 2 KCl_{(aq)}$$

$$MnO_4^-{}_{(aq)} + C_2O_4^{2-}{}_{(aq)} \rightarrow Mn^{2+}_{(aq)} + CO_{2(g)} \quad \text{Acidic}$$

$$Cr_2O_7^{2-}{}_{(aq)} + Cl^-_{(aq)} \rightarrow Cr^{3+}_{(aq)} + Cl_{2(aq)} \quad \text{Acidic}$$

$$CN^-_{(aq)} + MnO_4^-{}_{(aq)} \rightarrow CNO^-_{(aq)} \; MnO_{2(s)} \quad \text{Basic}$$

$$NO_2^-{}_{(aq)} + Al_{(s)} \rightarrow NH_{3(aq)} + Al(OH)_4^-{}_{(aq)} \quad \text{Basic}$$

$$Cr(OH)_{3(s)} + ClO^-_{(aq)} \rightarrow CrO_4^{2-}{}_{(aq)} + Cl_{2(g)} \quad \text{Basic}$$

$$6e^- + 7H^+ + NO_2^- \longrightarrow NH_3 + 2H_2O$$

$$4H_2O + Al \longrightarrow Al(OH)_4^- + 4H^+ + 3e^- \quad (2)$$

$$6e^- + 7H^+ + NO_2^- \longrightarrow NH_3 + 2H_2O$$

$$6H_2O + 2Al \longrightarrow 2Al(OH)_4^- + 8H^+ + 6e^-$$

$+10OH^-$

$$OH^- + 5H_2O + 2Al + NO_2^- \longrightarrow 2Al(OH)_4^- + NH_3 + H_2O$$

Predicting Redox Products

For each of the following reactions, write a BALANCED equation, coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. **Omit formulas for any ions or molecules that are unchanged by the reaction.**

Magnesium ribbon is burned in oxygen.

$2Mg + O_2 \rightarrow 2MgO$

Acidified solutions of potassium permanganate and iron (II) nitrate are mixed together.

$8H^+ + 5Fe^{2+} + MnO_4^- \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

A piece of copper wire is placed in a solution of silver nitrate.

$Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$

Chlorine gas is bubbled into a solution of magnesium bromide.

$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$

Bromine gas is bubbled into a solution of dilute sodium hydroxide.

$2Br_2 + 4OH^- \rightarrow 2BrO^- + 2Br^- + 2H_2O$

A solution of potassium permanganate is mixed with an alkaline solution of sodium sulfite.

$H_2O + 2MnO_4^- + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-} + 2OH^-$

Acidified potassium permanganate solution is added to an acidic solution of hydrogen peroxide.

$6H^+ + 2MnO_4^- + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

$Fe^{2+} \longrightarrow Fe^{3+} + e^-$ ×5

$5e^- \; 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$

$5Fe^{2+} \longrightarrow 5Fe^{3+} + 5e^-$

$2e^- \; Br_2 + \text{OH} \longrightarrow 2Br^-$

$Br_2 + 2H_2O \longrightarrow 2BrO^- + 4H^+ + 2e^-$

$2Br_2 + 2H_2O \longrightarrow 2Br^- + 2BrO^- + 4H^+$

$+4\,OH^- \quad + \quad 4\,OH^-$

$2Br_2 + 4OH^- + 2H_2O \longrightarrow 2Br^- + 2BrO^- + 2H_2O$

$MnO_4^- + SO_3^{2-} \longrightarrow MnO_2 + SO_4^{2-}$

$3e^- \; 4H^+ + MnO_4^- \longrightarrow MnO_2 + 2H_2O$

$H_2O \quad SO_3^{2-} \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$

$2H^+ \quad MnO_4^- + SO_3^{2-} \longrightarrow MnO_2 + SO_4^{2-} + H_2O$

$+2OH^- \qquad\qquad + 2OH^-$

$2H_2O + MnO_4^- + SO_3^{2-} \longrightarrow MnO_2 + SO_4^{2-} + 2OH^- + H_2O$

$$MnO_4^- + H_2O_2 \longrightarrow Mn^{2+} + O_2$$

$$5e^- + 8H^+ \quad MnO_4^- \longrightarrow Mn^{2+} + 4H_2O \quad (2)$$

$$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^- \quad (5)$$

$$10e^- + 6H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 8H_2O$$

$$5H_2O_2 \longrightarrow 5O_2 + 10H^+ + 10e^-$$

$$6H^+ + 2MnO_4^- + 5H_2O_2 \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

Mixed Word Equations

For each of the following reactions, write a BALANCED equation, coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. **Omit formulas for any ions or molecules that are unchanged by the reaction.**

a) Manganese (II) nitrate solution is mixed with sodium hydroxide solution.

$Mn^{2+} + 2OH^- \rightarrow Mn(OH)_2$

b) Equal volumes of dilute equimolar solutions of sodium carbonate and hydrochloric acid are mixed.

$CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$

c) An excess of sodium hydroxide solution is added to a solution of aluminum chloride.

$Al^{3+} + 4OH^- \rightarrow Al(OH)_4^-$

d) Dilute acetic acid solution is added to solid magnesium carbonate.

$HC_2H_3O_2 + MgCO_3 \rightarrow Mg^{2+} + H_2O + CO_2 + C_2H_3O_2^-$

e) The hydrocarbon hexane is burned in excess oxygen.

$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$

f) Equimolar amounts of trisodium phosphate and hydrogen chloride, both in solution, are mixed.

$PO_4^{3-} + 3H^+ \rightarrow H_3PO_4$

g) Iron (III) nitrate solution is mixed with potassium thiocyanate solution

$Fe^{3+} + SCN^- \rightarrow FeSCN^{2+}$

h) Metallic copper is heated with concentrated nitric acid.

$4H^+ + 2NO_3^- + Cu \rightarrow Cu^{2+} + NO_2 + H_2O$

i) Manganese (IV) oxide is added to warm, concentrated hydrobromic acid.

$2Br^- + 4H^+ + MnO_2 \rightarrow Mn^{2+} + 2H_2O + Br_2$

j) Hydrogen peroxide is added to an acidified solution of potassium dichromate.

$8H^+ + Cr_2O_7^{2-} + 3H_2O_2 \rightarrow 2Cr^{3+} + 3O_2 + 7H_2O$

k) Calcium metal is added to a dilute solution of hydrochloric acid.

$Ca + 2H^+ \rightarrow Ca^{2+} + H_2$

l) A solution of sulfuric acid is added to a solution of sodium hydroxide until the same number of moles of each compound has been added.

$H^+ + OH^- \rightarrow H_2O$ ~~or~~ ~~$H_2SO_4 \rightarrow 2H^+$~~

m) Sulfur dioxide gas is bubble through an acidified solution of potassium permanganate.

$2H_2O + 5SO_2 + 2MnO_4^- \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$

n) A solution of sodium hydroxide is added to a solution of sodium dihydrogen phosphate until the same number of moles of each compound had been added.

$H_2PO_4^- + OH^- \rightarrow HPO_4^{2-} + H_2O$

o) A solution containing tin (II) ions is added to an acidified solution of potassium dichromate.

$14H^+ + Cr_2O_7^{2-} + 3Sn^{2+} \rightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$

p) A solution of ammonia is added to ferric nitrate.

$Fe^{3+} + NH_3 \rightarrow Fe(NH_3)_6^{3+}$

q) A solution of concentrated hydrochloric acid is added to silver chloride forming a complex ion.

$AgCl + Cl^- \rightarrow AgCl_2^-$

r) Chlorine gas is bubbled into dilute sodium hydroxide solution.

$4OH^- + 2Cl_2 \rightarrow 2ClO^- + 2Cl^- + 2H_2O$

s) A solution of tin (II) chloride is added to acidified solution of potassium permanganate.

$5Sn^{2+} + 16H^+ + 2MnO_4^- \rightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$

a $Mn(NO_3)_2 + 2NaOH \longrightarrow Mn(OH)_2 + 2NaNO_3$

~~$Mn^{2+} \rightarrow MnO_2$~~

$Mn^{2+} + 2OH^- \longrightarrow Mn(OH)_2$

b $Na_2CO_3 + 2HCl \longrightarrow NaCl + CO_2 + H_2O$

$CO_3^{2-} + 2H^+ \longrightarrow CO_2 + H_2O$

c $AlCl_3 + NaOH \longrightarrow$

$Al^{3+} + 4OH^- \rightarrow Al(OH)_4^-$

d $MgCO_3 + 2HC_2H_3O_2 \longrightarrow Mg(C_2H_3O_2)_2 + H_2O + CO_2$

~~$2H^+$~~ $+ MgCO_3 \longrightarrow Mg^{2+} + H_2O + CO_2 + 2C_2H_3O_2^-$

$2HC_2H_3O_2$

e $2C_6H_{14} + 19O_2 \longrightarrow 12CO_2 + 14H_2O$.

f $Na_3PO_4 + 3HCl \rightarrow H_3PO_4 + 3NaCl$

$PO_4^{3-} + 3H^+ \longrightarrow H_3PO_4$

g $Fe(NO_3)_3 + KSCN \longrightarrow FeSCN^{2+} + KNO_3$

~~K~~ $Fe^{3+} + SCN^- \longrightarrow FeSCN^{2+}$

h $Cu + HNO_3 \longrightarrow$

$Cu \longrightarrow Cu^{2+} + 2e^-$

$e^- + 2H^+ \; NO_3^- \longrightarrow NO_2 + H_2O$ (2)

$Cu \longrightarrow Cu^{2+} + 2e^-$

$2e^- + 4H^+ + 2NO_3^- \longrightarrow NO_2 + H_2O$

$4H^+ + 2NO_3^- + Cu \longrightarrow Cu^{2+} + NO_2 + H_2O$

i $MnO_2 + HBr \longrightarrow$

$2e^- \; 4H^+ \; MnO_2 \longrightarrow Mn^{2+} + 2H_2O$ (1)

$2Br^- \longrightarrow Br_2 + 2e^-$

$2e^- + 4H^+ + MnO_2 \longrightarrow Mn^{2+} + 2H_2O$

$2Br^- \longrightarrow 2Br_2 + 4e^-$

$4H^+ + 2Br^- + MnO_2 \longrightarrow Mn^{2+} + 2H_2O + Br_2$

j $H_2O_2 + K_2Cr_2O_7$

$6e^- + 14H^+ \; Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$ (3)

$6e^- + 8H^+ + Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$3H_2O_2 \longrightarrow 3O_2 + 6H^+ + 6e^-$

$8H^+ + Cr_2O_7^{2-} + 3H_2O_2 \longrightarrow 2Cr^{3+} + 3O_2 + 7H_2O$

k $Ca + 2HCl \longrightarrow CaCl_2 + H_2$

$Ca + 2H^+ \longrightarrow Ca^{2+} + H_2$

l $H_2SO_4 + 2NaOH \longrightarrow 2H_2O + Na_2SO_4$

$SO_2 + KMnO_4$

$2H_2O + SO_2 \longrightarrow SO_4^{2-} + 4H^+ + 2e^-$ (5)

m $5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O$ (2)

$2H_2O + 5SO_2 \longrightarrow 5SO_4^{2-} + 4H^+ + 10e^-$

$10e^- + 16H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 8H_2O$

$5SO_2 + 2MnO_4^- \longrightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$

$NaH_2PO_4 + NaOH \rightarrow$

$H_2PO_4^- + OH^- \longrightarrow HPO_4^{2-} + H_2O$

n $Sn^{2+} + K_2Cr_2O_7 \rightarrow$

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$ (3)

$6e^- + 14H^+ + Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O$

$3Sn^{2+} \longrightarrow 3Sn^{4+} + 6e^-$

$14H^+ + Cr_2O_7^{2-} + 3Sn^{2+} \longrightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$

P $NH_3 + Fe(NO_3)_3$

$Fe(NH_3)_6^{3+}$

R $Cl_2 + NaOH$

$2H_2O + Cl_2 \longrightarrow 2ClO^- + 4H^+ + 2e^-$

$2e^- + Cl_2 \longrightarrow 2Cl^-$

$2H_2O + 2Cl_2 \longrightarrow 2ClO^- + 2Cl^- + 4H^+$

$+ 4OH^- \qquad + 4OH^-$

$2H_2O + 4OH^- + 2Cl_2 \longrightarrow 2ClO^- + 2Cl^- + 2H_2O$

S) $Sn(NO_3)_2 + KMnO_4$

$Sn^{2+} \longrightarrow Sn^{4+} + 2e^- \quad (5)$

$5e^- + 8H^+ + MnO_4^- \longrightarrow Mn^{2+} + 4H_2O \quad (2)$

$5Sn^{2+} \longrightarrow 5Sn^{4+} + 10e^-$

$10e^- + 16H^+ + 2MnO_4^- \longrightarrow 2Mn^{2+} + 8H_2O$

$5Sn^{2+} + 16H^+ + 2MnO_4^- \longrightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$